Remarks upon the Phenomena attending the Disappearance, by Rotation, of the great Solar Spot of August 4th, 1862, as recorded by both Helio-photography and ordinary Telescopic Observation. By the Rev. F. Howlett.

Mr. Howlett, at the December Meeting, addressed the Society as follows:—

After the able remarks which have recently appeared in print respecting the comparative merits, in certain points, of celestial photography and telescopic observation—in connexion chiefly with the solar, and also the lunar surface—it might be deemed almost more than superfluous on my part to wish to bring the subject again before your attention this evening.

Mr. Dawes has alluded to the matter in a very instructive manner, both in an article which appeared in the *London Review* on the 18th of October last, and elsewhere; as also has Mr. Birt, in the columns of the same journal for Nov. 22 of the present year.

But the phenomena attending the disappearance, by rotation, of the very remarkable group of solar spots on the 4th of August last, and the observations then made, photographic and otherwise, in connexion with those phenomena, seem to bear so strongly upon one or two of the more *interesting* and at the same time most *warmly contested* points regarding the Sun's surface, that I hope I shall be pardoned for desiring to make you acquainted with the nature of a few of my own observations concerning the disappearance of this said group, as contrasted with the only photographic record of it which I have yet heard of, more especially since I was, I believe, the first to detect the discrepancy in this particular instance, in the course of a most interesting correspondence, which now for some little time has been maintained between Professor Selwyn and myself on such subjects; and I was permitted to make the case known in public on the 3d of October, before the members of the British Association assembled at Cambridge—as some here present may possibly remember.

It will of course be understood that it is in no carping spirit (which on every account would utterly unbecome me) that I venture to say that at times the photographic record may stand corrected by the simply telescopic one; the highest honours of this Society have recently, and doubtless most justly, been awarded to that distinguished member of our Society, whom we have now the great good fortune to own as one of our Secretaries, for his extraordinary success in applying the art of photography to celestial investigations of the highest interest; and earnestly do we all wish him every future success therein also, that both he and every lover of science could possibly desire.

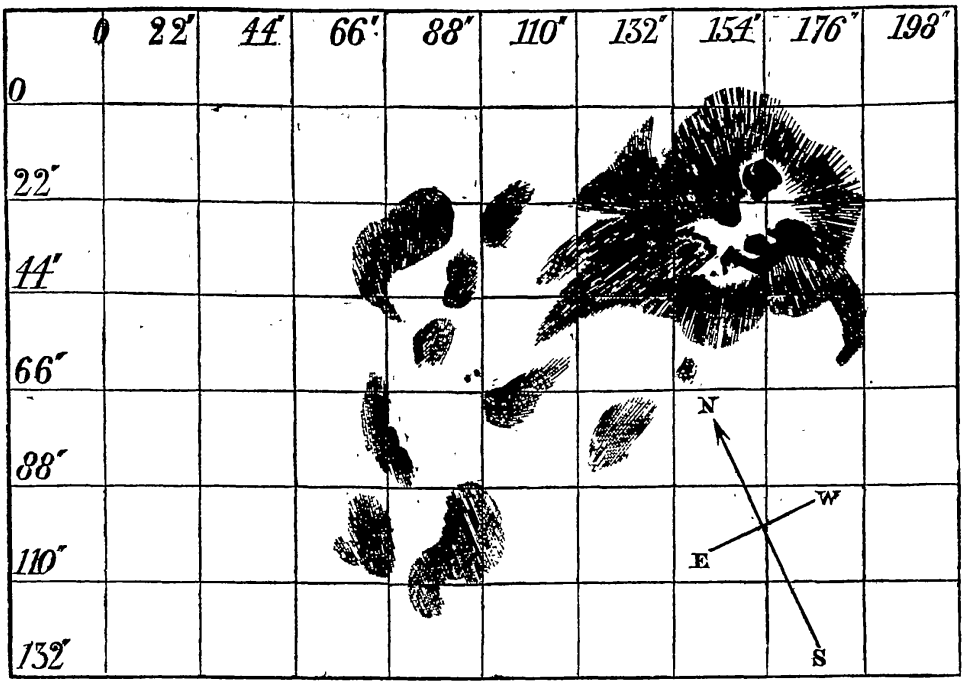
But not to be further tedious I would at once proceed to

remark, that the magnificent group in question (lettered ϱ in my record of Solar Spots), which passed off the disk on the evening of August 4th, was not observed by me before the afternoon of July 25th, by which time it had already advanced a considerable distance upon the Sun's surface. As seen near the centre of the disk, this group subtended about 4′ 30″ of arc, which would be equivalent to about 122,000 miles.

A carefully sketched series of drawings of the same, including twenty-two delineations, taken upon ten different days (and which are seen in sheets 83 to 86 inclusive), may be compared with the helio-autographs presented by Prof. Selwyn to the Royal Astronomical Society. Some of the drawings—those more particularly which illustrate the disappearance of the principal spot, and the photographic discrepancy on that occasion, have been re-copied in the diagrams on a scale of about ten feet to the solar diameter, which would give about four inches to one minute of arc, an amplification which, though not the best truly for distinct definition, may readily be obtained by the aid of a telescope of even not more than $2\frac{3}{4}$ inches aperture, and a power of about 160 diameters, by projecting the Sun's image upon a cardboard or other suitable screen, placed in a perfectly darkened chamber, at a distance of 8 feet from the eye-glass; and which arrangement enables me to observe and study the faculæ and solar surface generally, with remarkable facility and satisfaction. But the most effectual definition, amplification, and general management of the whole apparatus of both telescope, screen, and darkening shutter, are obtained in a simple but instructive method, by placing the screen on an easel, at the distance of about 4 ft. 2 in. from the eye-glass of my telescope—either one of the equatoreally mounted Sheepshanks' instruments, No. 4, belonging to the Royal Astronomical Society, $3\frac{3}{4}$ inches aperture, and 3 ft. 8 in. focal length, or a small Dollond of my own, of admirable definition and similar focal length, but of only $2\frac{3}{4}$ inches aperture, mounted upon a tripod stand, and armed with powers from 30 to 150 diameters. With a power of 80 diameters, the graduations of a kind of glass micrometer, ruled off into $\frac{1}{100}$ths of an inch, are seen beautifully projected upon a screen thus placed, (as also are any sun-spots or other solar phenomena that may chance to be in the field) each graduation meanwhile measuring half an inch in breadth, and comprising about 31 seconds of arc.

With regard, next, to the appearance of the group on July 25th, at $1^h\ 30^m$ P.M., I would direct attention to a remarkable mass of brilliant photospheric matter, at least 12,000 miles in length by 6,000 miles in breadth, (and embracing therefore a superficial area of not less than seventy-two million square miles), lying amidst the various associated nuclei of the principal spot, and completely insulated by a well-defined penumbra from the contiguous photosphere (fig. 1).

Fig. 1, 1862, July 25, 2·0 P.M.



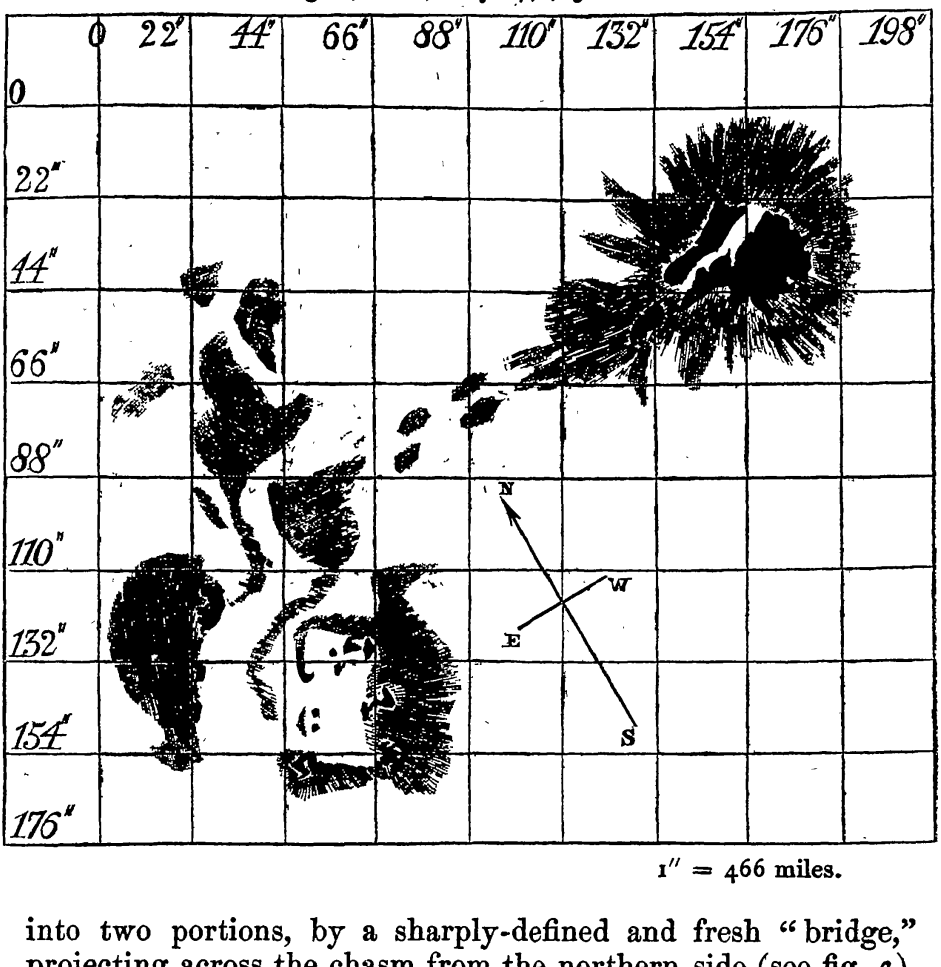
1″ = 466 miles.

On July 26th these nuclei had run into each other and become considerably enlarged, at the expense apparently of the bright patch; which last, either by sublimation, possibly, or a draining off sideways, or some kind of exhaustion, had become very much reduced in magnitude, as it was still more by $7^h\ 30^m$ A.M. on July 27th (see fig. 2), whilst, by $3^h\ 0^m$ P.M. on the same day, the patch was nearly obliterated, a slight hazy "bridge" alone remaining visible, and which in a feeble diffused form was faintly to be traced also on both the 28th and 29th July; but when I next observed the Sun on the 31st, this haze seemed to have entirely vanished. Some have thought that such a hazy film constantly accompanies a nucleus, but such is not my own impression. May not any extra appearance of haze be rather accounted for by the occurrence of phenomena similar to those which have just been described?

On July 31st, and August 1st, the great nucleus was grandly fringed by projections from the contiguous penumbral matter, often with sharp tooth-like terminations, and the disposition of the subordinate spots and patches of penumbra was also very interesting and instructive, as indeed they had been during the whole period of their apparition. But the highest point of interest, perhaps, in connexion with this group, exhibited itself on the occasion of the gradual disappearance round the western limb on the evening of August 4th.

On the preceding day, indeed, the group, and more especially the principal nucleus, might be seen to be remarkably foreshortened, and to be about to be divided again, apparently

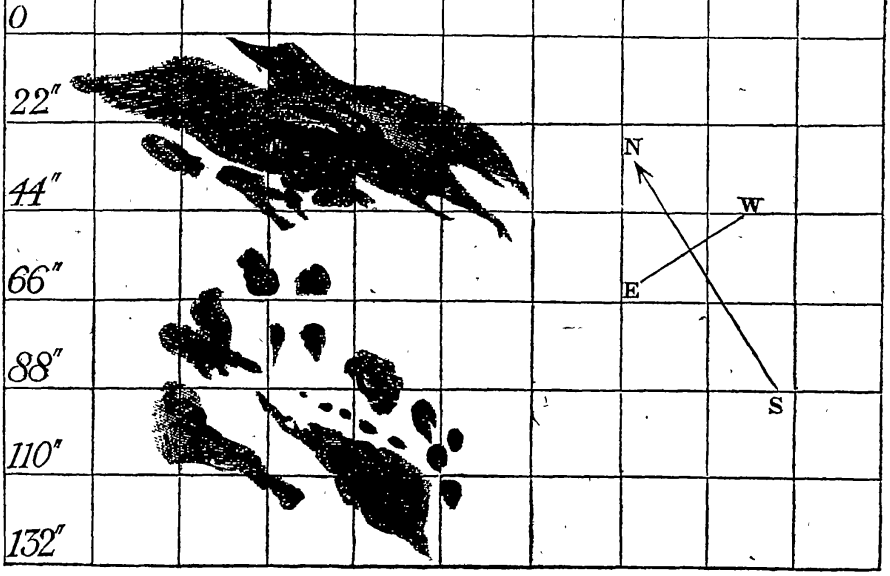
Fig. 2, 1862, July 27, 7·30 A.M.



1″ = 466 miles.

into two portions, by a sharply-defined and fresh "bridge," projecting across the chasm from the northern side (see fig. 3),

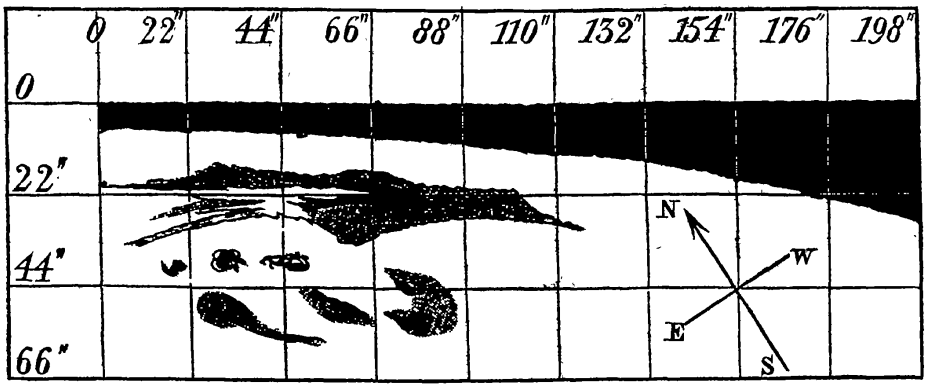
Fig. 3, 1862, Aug. 3, 6·40 A.M.



which feature (though springing then from the western side of the nucleus) had also characterised this spot during its earlier stages.

At $6^h\ 30^m$, on the morning of August 4th, the nucleus and "bridge," and many of the subordinate details, were still very distinct, though of course they were extremely attenuated, the nucleus then being, as nearly as I could judge, about twelve seconds of arc from the Sun's north-west margin; by far the greater portion of the penumbra, moreover, as Mr. Birt observed in his communication of October 20th last to the *London Review*, lying on its following or eastern side (see fig. 4).

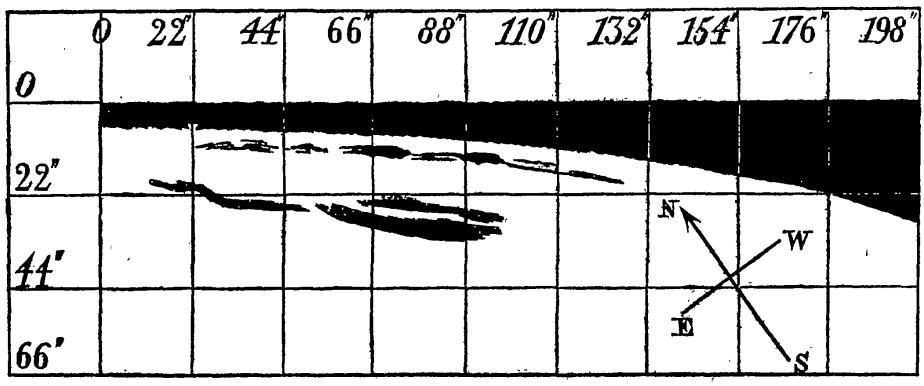
Fig. 4, 1862, Aug. 4, 7·0 A.M.



1″ = 466 miles.

By $3^h\ 50^m$ P.M., the nucleus, now reduced to a mere line, yet (owing to the admirable state of the atmosphere that day in east Sussex) *clearly* to be distinguished from its adjoining penumbra, could not have been more than from 3″ to 4″ from the limb, which latter, however, as yet, was certainly not broken (see fig. 5).

Fig. 5, 1862, Aug. 4, 3·50 P.M.

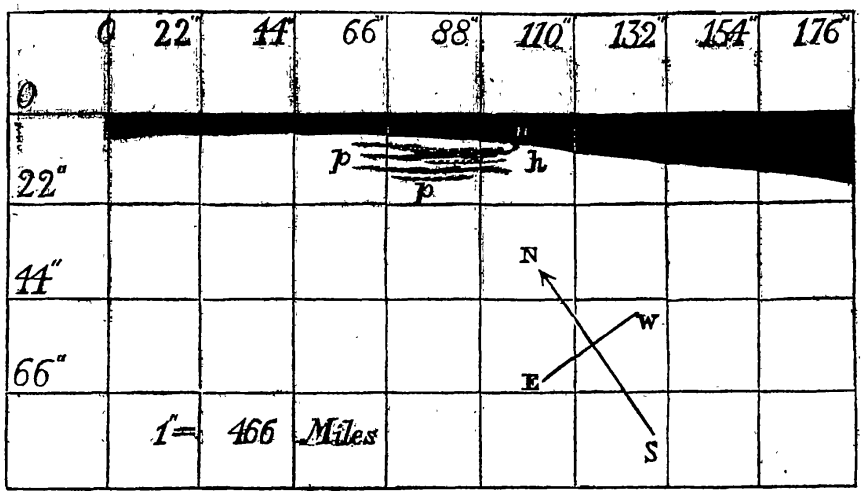


Pressing parochial business unfortunately prevented my observing the disk again till about 6 P.M., by which time the nucleus had completely disappeared, portions of its penumbra,

however, still remaining visible, as well as other patches of penumbræ adjoining.

And now it was that I am confident I could plainly perceive a *small notch* in the Sun's margin, precisely over the place where the great nucleus must have been existing (see fig. 6): and

Fig. 6, 1862, Aug. 4, 6 P.E.



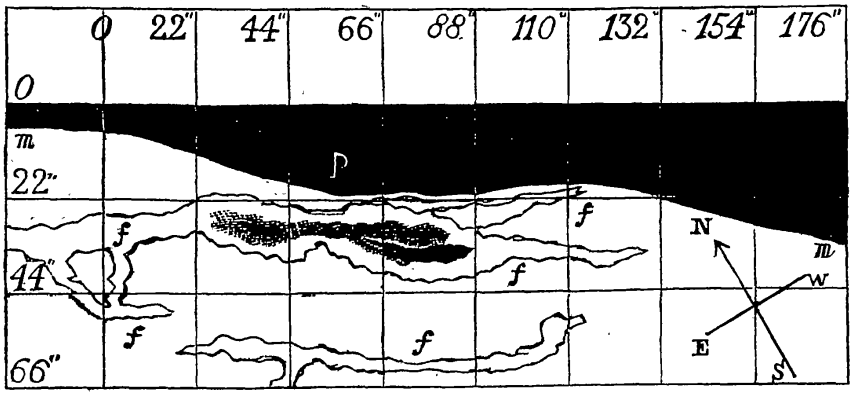
n, true notch in Sun's margin; *h*, hillock of facula; *p*, penumbral patches of great group.

it struck me that it was not caused so much by any deficiency in the circular limb of the Sun itself, but rather by reason of abnormally heaped up masses of the contiguous photosphere; which had perhaps been swept away, as it were, from the area occupied by the nucleus and penumbra, in like manner as a slight fall of snow might have been swept away from off a gravel path, and thus have been thrown up a little on each side. The portion of penumbra, in fact, which still remained visible, appeared to me to form the bottom of a shallow valley, seen obliquely over one of the elevations by which it was bounded, the right-hand, or south, bank (as seen in the inverted image) being the higher of the two.

Now all the foregoing observations had been communicated by me in a letter to Prof. Selwyn before I had any knowledge whether or no his photographer (Mr. Titterton, of Ely) had obtained "autographs" of the Sun on the day in question. A reply to my letter came to me shortly afterwards, in the form of two separate "autographs," taken respectively at the hours of $10^h\ 15^m$ and $11^h\ 30^m$ of the notable morning of August 4. But what struck me as very remarkable, was, that at the time when I had plainly observed and measured a brilliant streak of photosphere extending between the nucleus and the Sun's limb (and which I continued to observe and measure, at intervals, for nine hours afterwards), the autographs presented no appearance whatever of this streak, but

exhibited instead the appearance of a large notch or depression in the limb, approximately about 2′ of arc in length from N. to S., and 15″ or 16″ in depth from E. to W. See Fig. 7.

Fig. 7, 1862, Aug. 4, 10·30 A.M. (as represented in photograph).



1″ = 466 miles.

f stands for faculæ, P for pseudo gap in margin of Sun, *m* for normal margin of Sun; the subordinate spots only of the great group are yet visible, as shown in Figs. 4 and 5.

But this extraordinary depression, though hailed at the first by some of the advocates of the cavernous nature of the solar spots, as an almost triumphant proof of their views, went, as we have just seen, to prove *too much;* and, indeed, had the collodion been exposed to the solar rays for a somewhat longer period, in order that the comparatively dusky solar margin might have sufficiently depicted itself, no notch of any such dimensions (or, indeed, any notch at all) could possibly have appeared; and though Prof. Selwyn believes that this lengthened exposure would have spoiled, in all probability, the middle portions of the photograph (where, for instance, in sheet 86, the group lettered σ in my record is situated), yet in such a case it would only be requisite of course to take other negatives more especially adapted to the central parts of the disk.

Whilst on this part of my subject I would take the opportunity of mentioning that the helio-autographs of August 4th are not the only instances which present the appearance of such a pseudo-gap in the Sun's margin, whereby the existence of a large spot, when close to the limb, is completely ignored, sometimes.

Another such instance occurred in the photograph taken by Mr. Titterton on October 1st. Several of those who were attending at that time the meeting of the British Association, at Cambridge, would gladly have availed themselves of another of those rarely occurring chances of watching a large group fairly off the disk. Mr. Alexander Herschel did have such an opportunity at Collingwood, near Hawkhurst, that day, though

no notch was at any time apparent. Previously to leaving home I had requested Mr. Herschel to keep an eye on the group in question, and I received from him a letter, from which the following is an extract:—

"*Collingwood, Hawkhurst,*
"*Oct. 1st*, 1862.

"I send you in reply . . . a sketch of the Sun's appearance to-day. I missed the breaking of the white line, but the scale of the sketch, which is 1 inch to a minute, will show you that I saw it at $10^h\ 50^m$ A.M., to within 5 or 6 seconds of the Sun's limb, without any signs of the white line breaking."

And yet in the photograph taken that day at Ely the principal spot of the group is ignored, a shallow notch occupying its place, when, in point of fact, no such notch existed.

But notwithstanding any such discrepancies, allow me here to plead for the cavernous nature of the solar spots. For whilst jealously avoiding all desire to take any undue kind of argument from helio-photography, in its present stage, in support of the theory (which is also my own firm persuasion), that the solar spots are indeed cavities in the Sun's surface, I am not willing to be shaken in my belief that the photographic testimony bears most strongly in favour of that theory.

Photography, indeed, at times, would seem to wish to prove too much, as we said, but all its evidence, surely, runs in the same direction. It proves, surely, in agreement with the best eye observations, that the faculæ *undoubtedly* are raised billows or mountains, as it were, of photospheric matter, the crests of which (as Padre Secchi pointed out to me when lately at Rome) are necessarily not very visible when situated in the more *central* parts of the disk, where they are seen through the least perspective depth of the solar atmosphere, and where, in consequence, all similarly luminous photospheric matter, whether raised or otherwise, appears nearly alike brilliant; but which faculæ naturally exhibit themselves in far stronger relief towards the *marginal* portions of the disk, because that the rays which emanate from their lofty crests have to traverse, in their passage to our eyes, a far smaller amount of solar atmosphere than those rays have which emanate from their bases, and from the mean photospheric level above which the faculæ rise.

But may it not be argued thus, also, that not only are the faculæ elevations, but that the nuclei and penumbræ are depressions in the solar surface, and not clouds impending over it?

For if the solar spots were clouds, would they not (especially when anything like the size of the group of August 4th, 1862) exhibit much more frequent appearances of notches than they do?

They would surely be often seen in dark relief upon the Sun's limb, something after the way in which, at the beginning or close of a transit, the planets *Mercury* or *Venus* may be seen to produce an apparent indentation. And this appearance ought to take place, in the case of spots or groups of large magnitude, whether they were at a greater or less distance from the Sun's surface. Whereas, supposing them to be indeed cavities sunk in the spherical solar orb, then it seems clear that, even with the addition of the upheaved faculæ to enhance the effect, the phenomenon of a notch must be, *as it is*, exceedingly *rare*, and without the faculæ be well-nigh impossible.

But all the conditions requisite for forming the appearance of a small depression in the Sun's Limb were fulfilled on the evening of 4th of August. A group of unusual magnitude was passing off: there were mountain-like ridges of faculæ plainly conspicuous in the immediate neighbourhood of the same, and the eye of a spectator upon the earth would be looking along the shallow *trough* of the solar penumbræ, nucleus, and faculæ, in its greatest extent.

Another objection, finally, to the spots being cloudy masses appears to be this. Would it be possible for clouds to maintain such a comparatively *black tint* when immediately superimposed over the intensely incandescent surface (if it be incandescent, really, as well as brilliant) of the orb of the Sun?

RECENT PUBLICATION.

Sur deux Inégalités d'une grandeur remarquable dans les Apparitions de la Comète de Halley. Par A. J. Angström. (Extrait des *Actes de la Société Royale des Sciences d'Upsal*, Sér. iii. t. iv.) Upsal, 1862.*

The author remarks that Mr. Hind having succeeded in obtaining from the ancient accounts the appearances of Halley's Comet, as far back as the year 10 B.C., with considerable probability, he (M. Angström) was by these dates enabled to show the existence of two periodic Inequalities in the time of revolution of the Comet, surpassing as well in their magnitude as in the length of their period all the known Inequalities in the Planetary and Lunar Theories. The greater inequality, as regards the time of revolution of the Comet, is the more interesting, inasmuch as it depends on the known relation

* Mr. Carrington gave an account of this Memoir at the January Meeting, and he particularly called attention to the comparatively small amount of labour expended in obtaining such important results.—Ed.

(5 *Sat.* — 2 *Jup.* = 0 nearly) between the times of revolution of *Jupiter* and *Saturn*. The assumed data were—

Times of the Appearances of the Comet according to Mr. Hind.

— 10,20	451,50	912,25	1378,85
+ 66,07	530,84	989,70	1456,44
141,24	608,80	1066,25	1531,65
218,26	684,80	1145,30	1607,82 (N. S.)
295,25	760,44	1223,52	1682,70
373,84	837,26	1301,81	1759,19
			1835,87

thus comprising 24 complete revolutions, and giving a mean period

$$\tau = 76{,}92 \quad \text{Julian years};$$

or, taking the Julian year for the unit of time, the mean velocity of the Comet is $= 4^\circ\, 40'\, 48''{\cdot}72$.

Taking, then, the mean year 913,97 as the epoch, and the above value $\tau = 76{,}92$ as the mean time of revolution, this gives for the differences between the actual and calculated times of appearance, reckoned in Julian years, the series of values (already calculated by M. Mädler):—

−1,13	−0,95	−1,72	+3,27
−1,78	+1,47	−1,18	+4,04
−3,53	+2,51	−1,55	+2,31
−3,45	+1,59	+0,58	+1,48
−3,36	+0,27	+1,88	−0,46
−1,69	+0,21	+3,25	−0,89
			−1,13

These differences are laid down as ordinates in the plate annexed to the Memoir, the unit of distance for the abscissæ being the mean period τ, and that for the ordinates the half of a Julian year. And the form of the broken line joining the extremities of the ordinates, suggests the existence of the two inequalities (reckoned in Julian years):—

$$= 1{,}5 \sin\left((13\ \text{Com.} - 2\ \text{Jup.})\, n\tau + 13^{\circ}{\cdot}6\right)$$

$$\propto 2{,}3 \sin\left((\text{Jup.} + \text{Sat.} - 9\ \text{Com.})\, n\tau + 231^\circ\ 1'\right)$$

the former depending exclusively on *Jupiter*, but the latter on *Jupiter* and *Saturn* conjointly.

A numerical discussion of the data by the method of least squares, on the foregoing basis, leads to the corrected formula for the time of appearance:—

$$A = 913{,}97 + n\tau + 1{,}4626 \sin\left((13\ \text{Com.} - 2\ \text{Jup.})\, n\tau + 19^\circ\, 14'{\cdot}3\right)$$
$$+ 2{,}1642 \sin\left((\text{Jup.} + \text{Sat.} - 9\ \text{Com.})\, n\tau + 233^\circ 39'{\cdot}1\right),$$

with the corrected value $\tau = 76{,}93$, and resulting value $4^\circ\ 40'\ 46''{\cdot}6$ for the period and mean annual velocity of the Comet; and then with Hansen's values,

$$\text{Jup.} = 30^\circ\ 20'\ 56''{\cdot}7, \qquad \text{Sat.} = 12^\circ\ 36'\ 16''{\cdot}1,$$

the numerical values for the arguments are found to be

$$13\ \text{Com.} - 2\ \text{Jup.} = 8'\ 10''{\cdot}4 = 2649{,}7\ \text{Jul. years} = 34{,}44\ \tau$$
$$\text{Jup.} + \text{Sat.} - 9\ \text{Com.} = 27'\ 15''{\cdot}2 = 782{,}38\ \text{,,} = 10{,}30\ \tau.$$

The final comparison of the formula with the data is found to present a very satisfactory accordance. The author remarks that by the combined action of the two inequalities, *the time of appearance of the Comet might be accelerated or retarded* from one revolution to another, *by about a year and a half.*

Minor Planet (75). Discovered by Dr. C. H. F. Peters, at the Hamilton College Observatory, 22d Sept. 1862.

The following elements, calculated by him, are given (*Ast. Nach.* No. 1399):—

Epoch 1862, Nov. 0·0, Washington M.T.

M	=	30	0	10·93	
π	=	334	40	12·13	Mean Equinox 1862·0.
Ω	=	359	52	19·09	
i	=	4	59	8·75	
φ	=	17	47	7·24	
μ	=			815″·1760	
log a	=			0·4258368	